the former is inserted into the third-digit slip of the long flexor tendon; the latter, or true accessorius, is attached to the front of the two inner tendons, and is rather larger. The tendons for the toes are thus complex in their mode of formation; for plantaris and flexor digitorum, united with flexor hallucis and the accessorii, form but one common series of tendons. The flexors digitorum and hallucis first unite; these are joined by the plantaris; and the conjoined tendon receives the accessorii: thus the outer-toe tendon is formed by the outer accessorius and a slip from the common flexor; the inner receives the principal body of the flexor hallucis and a slip of the others, while the middle has one single tendon of composite origin.

PROCEEDINGS OF LEARNED SOCIETIES.

ROYAL SOCIETY.

Feb. 11, 1869.—Dr. W. B. Carpenter, Vice-President, in the Chair.

"On the Structure and Development of the Skull of the Common Fowl (*Gallus domesticus*)." By W. Kitchen Parker, F.R.S.

In a former paper (Phil. Trans. 1866, vol. clvi. part 1, pp. 113–183, plates 7–15) I described the structure and development of the skull in the Ostrich tribe, and the structure of the adult skull of the Tinamou—a bird which connects the Fowls with the Ostriches, but which has an essentially struthious skull.

That paper was given as the first of a proposed series, the subsequent communications to be more special (treating of one species at a time) and carrying the study of the development of the cranium and face to much earlier stages than was practicable in the case of the struthious birds.

Several years ago Professor Huxley strongly advised me to concentrate my attention for some considerable time on the morphology of the skull of the Common Fowl; that excellent advice was at length taken, and the paper now offered is the result.

A full examination of the earlier conditions of the chick's skull has cost me much anxious labour; but my supply of embryonic birds (through the kindness of friends)* was very copious, and in time the structure of the early conditions of the skull became manifest to me.

The *earliest* modifications undergone by the embryonic head are not given in this paper: they are already well known to embryologists; and my purpose is not to describe the general development of the embryo, but merely the skeletal parts of the head.

These parts are fairly differentiated from the other tissues on the fourth day of incubation, when the head of the chick is a quarter

* Dr. Murie is especially to be thanked for his most painstaking kindness in this respect.

of an inch (3 lines) in length; this in my paper is termed the "first stage." The next stage is that of the chick with a head from 4 to 5 lines in length, the third 8 to 9 lines, and so on. The ripe chick characterizes the "fifth stage;" and then I have worked out the skull of the chicken when three weeks, two months, three months, and from six to nine months old, the skull of the aged Fowl forming the "last stage."

During all this time (from their first appearance to their highly consolidated condition in old age) the skeletal parts are undergoing continual change, obliteration of almost all traces of the composite condition of the early skull being the result—except where there is a hinge, for there the parts retain perfect mobility.

Here it may be remarked that although the Fowl is only an approach to what may be called a typical Bird, yet its skull presents a much greater degree of coalescence of primary centres than might have been expected from a type which is removed so few steps from the semistruthious Tinamou, a bird which retains so many of its cranial sutures.

The multiplicity of parts in the Bird's skull at certain stages very accurately represents what is persistent in the Fish, in the Reptile, and to some degree in certain Mammals; but the skull at first is as simple as that of a Lamprey or a Shark, and, in the Bird above all other Vertebrates, reverts in adult age to its primordial simplicity—all, or nearly all, its metamorphic changes having vanished and left no trace behind them.

Although in this memoir I have no business with the Fish, yet all along I have worked at the Fish equally with the Bird, the lower type being taken as a guide through the intricacies of the higher; and here the Cartilaginous and the Osseous Fishes are never fairly out of sight. The Reptile, and especially the Lizard, has been less helpful to me, on account of its great specialization.

On the fourth day of incubation the cranial part of the notochord is two-thirds the length of the primordial skull, but it does not quite reach the pituitary body; it lies therefore entirely in the occipito-otic region. The fore part of the skull-base extends horizontally very little in front of the pituitary space; this arises from the fact that the "mesocephalic flexure" has turned the "horns of the trabeculæ" under the head. Thus at this stage the nasal, oral, and postoral clefts are all seen on the under surface of the head and neck of the chick. At this time the facial arches have begun to chondrify; but only the quadrate, the Meckelian rod, and the lower thyro-hyal are really cartilaginous; the other parts are merely tracts of thickened blastema or indifferent tissue.

In the second stage an orbito-nasal septum has been formed; the "horns of the trabeculæ" have become the "nasal alæ," and an azygous bud of cartilage has grown downwards between them; this is the "prænasal" or snout cartilage; it is the *axis* of the intermaxillary region. At the commencement of this second stage the primordial skull stands on the same morphological level as that of the ripe embryo of the Sea-turtle; at the end of this stage it has become struthious; and now parosteal tracts (the angular, surangular, dentary, &c.) appear round the mandibular rod.

In this abstract I shall not trace the changes of the skull any further, but conclude with a few remarks on the nomenclature of certain splints, and as to the nature of the great basicranial bones.

Some years ago I found that certain birds (for instance the Emeu) possessed an additional maxillary bone on each side; knowing that the so-called "turbinal" of the Lizard and Snake was one of the maxillary series I set myself to find the homologies of these splints. Renaming the reptilian bones "prævomers," on account of their relation to the vomer, and supposing the feeble maxillaries of the Bird to represent them, I considered that the true maxillaries were to be found in those newly found cheek-bones of the Emeu and some other birds.

After discussion with Professor Huxley I have determined to drop the term "prævomer," and to call the supposed turbinal of the Lizard "septo-maxillary," and the additional bone in the Bird's face "postmaxillary."

In many Birds, but not in the Fowl, the "septo-maxillary" is largely represented—not, however, as a distinct osseous piece, but as an outgrowth of the true maxillary.

With regard to the basicranial bones, I have now satisfied myself that the "parasphenoid" of the Osseous Fish and the Batrachian reappears in the Bird as three osseous centres—all true "parostoses," as in the single piece of the lower types; these three pieces are, the "rostrum" of the basisphenoid and the two "basitemporals."

These three centres rapidly coalesce to form one piece, the exact counterpart of the Ichthyic and Batrachian bone; but just as this coalescence begins, ossification proceeds inwards from these "parostoses," and affects the overlying cartilage, the cartilage of the basisphenoidal region having no other osseous nuclei. This process of the extension inwards of ossification from a splint-bone to a cartilaginous rod or plate I have already called "osseous grafting" *.

In my former paper the basisphenoidal "rostrum" and "basitemporals" were classed with the endoskeletal bones; they will in the present paper be placed in the parosteal category, in accordance with their primordial condition.

By the careful following out of these and numerous other details I have corrected and added to my previous knowledge of the early morphological conditions of the Bird's cranium, and at the same time, I trust, have contributed to an enlarged and more accurate conception of the history and meaning of the Vertebrate skull in general.

March 18, 1869.—Dr. William Allen Miller, Treasurer and Vice-President, in the Chair.

"On the Structure of the Red Blood-corpuscle of Oviparous Vertebrata." By William S. Savory, F.R.S.

The red blood-cell has been perhaps more frequently and fully examined than any other animal structure; certainly none has

* See memoir "On the Shoulder-girdle and Sternum," Ray Soc. 1868, p. 10.

evoked such various and even contradictory opinions of its nature. But without attempting here any history of these, it may be shortly said that amongst the conclusions now, and for a long time past, generally accepted, a chief one is that a fundamental distinction exists between the red corpuscle of Mammalia and that of the other vertebrate classes—that the red cell of the oviparous vertebrata possesses a nucleus which is not to be found in the corpuscle of the other class. This great distinction between the classes has of late years been over and over again laid down in the strongest and most unqualified terms.

But I venture to ask for a still further examination of this important subject.

As the oviparous red cell is commonly seen, there can be no doubt whatever about the existence of a "nucleus" in its interior. It is too striking an object to escape any eye; but I submit that its existence is due to the circumstances under which the corpuscle is seen, and the mode in which it is prepared for examination. I think it can be shown that the so-called nucleus is the result of the changes which the substance of the corpuscle undergoes after death (and which are usually hastened and exaggerated by exposure), and the disturbance to which it is subjected in being mounted for the microscope. When a drop of blood is prepared for examination, little or no attention is given to the few seconds, more or less, which are consumed in the manipulation. It is usually either pressed or spread out on the glass slip, and often mixed with water or some other fluid. But it is possible to place blood-cells under the microscope for examination so quickly, and with such slight disturbance, that they may be satisfactorily examined before the nuclei have begun to form. They may then be shown to be absolutely structureless throughout; and, moreover, as the examination is continued the gradual formation of the nuclei can be traced. The chief points to be attended to are—to mount a drop of blood as quickly as possible, to avoid as much as possible any exposure to air, to avoid as much as practicable contact of any foreign substance with the drop, or any disturbance of it.

After many trials of various plans, I find that the following will often succeed sufficiently well. Having the microscope, and everything else which is required, conveniently arranged for immediate use, an assistant secures the animal which is to furnish the blood (say, a frog or a newt), in such a way that the operator may cleanly divide some superficial vessel, as the femoral or humeral artery. He then instantly touches the drop of blood which exudes with the under surface of the glass which is to be used as the cover, immediately places this very lightly upon the slide, and has the whole under the microscope with the least possible delay. Thus for several seconds the blood-cells may be seen without any trace of nuclei; then, as the observation is continued, these gradually, but at first very faintly, appear; and the study of their formation affords strong proof of their absence from the living cells.

The "nucleus" first appears as an indistinct shadowy substance, usually, but not always, about the centre of the cell. The outline of it can hardly, for some seconds, be defined; but it gradually grows more distinct. Often some small portion of the edge appears clear before the rest. At the same time the nucleus is seen to be paler than the surrounding substance. Synchronously with this change—and this is noteworthy—the outline of the corpuscle (the "cell-wall") becomes broader and darker. What was at first a mere edge of homogeneous substance, becomes at length a dark border sharply defined from the coloured matter within. Thus a corpuscle, at first absolutely structureless, homogeneous throughout, is seen gradually to be resolved into central substance or nucleus, external layer or cell-wall, and an intermediate, coloured though very transparent, substance. But—and this is significant—these changes are not always thus fully carried out. It not seldom happens that the nucleus does not appear as a central well-defined regularly oval mass. Sometimes it never forms so as to be clearly traced in outline, but remains as an irregular shapeless mass, in its greater portion very obscure. Sometimes only a small part, if any, of an edge can be recognized, most of it appearing to blend indefinitely with the rest of the cell-substance. Sometimes it happens that in many corpuscles the formation of a nucleus does not proceed even so far as this. No distinct separation of substance can anywhere be seen, but shadows, more or less deep, here and there indicate that there is greater aggregation of matter at some parts than at others. Occasionally some of the cells present throughout a granular aspect. I have almost invariably observed, too, a relation between the distinctness of the nucleus and of the cell-wall. When the nucleus is well defined, the cell-wall is strongly marked; when one is confused, the other is usually fainter. This, however, does not apply to colour; on the contrary, when the nucleus is least coloured it contrasts most strongly with the surrounding cell. As a rule, the wall of the cell is more strongly marked than the nucleus.

It will of course be said that the nuclei are present all the while, but are at first concealed by the surrounding substance—the contents of the cell. Thus the fact has been accounted for, that the nuclei are not so obvious at first as they subsequently become. But I think a careful comparison of cells will show that those in which a nucleus may be traced are not more transparent than others which are structureless; and, moreover, when one cell overlaps another, the lower one is seen through the upper clearly enough to show that the substance of these cells is sufficiently transparent to allow of a nucleus being discerned if it exists. When a nucleus is fully formed, it hides that portion of the outline of a cell which lies beneath it. How is it, then, if the nucleus is present from the first, that the portion of the cell over which it subsequently appears is, for a while, plainly seen?

The success of the observation is of course influenced by numerous circumstances. The rate at which the nuclei form in the corpuscles varies in different animals. I have usually found that in the common frog they are more prone to form than in many other animals—quicker than in most fishes, or even than in some birds. But this does not seem always to depend upon their larger size; for in the common newt the cells, which are larger than those of the frog, remain, as I have noticed, for a longer period without any appearance of nuclei. But even in the frog it can be satisfactorily demonstrated that the corpuscle is structureless.

I have found, too, that the observation succeeds best with the blood of animals which are healthy and vigorous. Thus the first observations upon fresh animals are usually the most satisfactory. After they have been repeatedly wounded or have lost much blood, the cells are more prone to undergo the changes which result in the production of nuclei.

Again, the formation of nuclei may be hastened, and their appearance rendered more distinct at last, by various reagents. Acids and many other reagents are well known to have this effect. The addition of a small quantity of water acts in the same way, but less energetically. It hastens the appearance of an indistinct nucleus, but interferes with the formation of a well-defined mass, so that, after the addition of water, neither the outline of the cell nor of the nucleus becomes so strongly marked as it often does without it. Exposure to air also promotes their formation; indeed, as a rule, the nuclei form best under simple exposure. Any disturbance of the drop, as by moving the point of a needle in it, certainly hastens the change; and perhaps it is influenced by temperature.

Sometimes, when the drop of blood has been skilfully mounted, the majority of cells will remain for a long while without any trace of nucleus; but, again, in almost every specimen, the nucleus in some few of the cells, particularly in those nearest the edges, begins to appear so rapidly that it is hardly possible to run over the whole field without finding some cells with an equivocal appearance.

It would follow, of course, from these observations that, if the living blood were examined in the vessels, the corpuscle would show no trace of any distinction of parts; and this is so. Indeed, in my earlier observations*, before I had learnt to mount a drop of blood for observation in a satisfactory manner, I examined, at some length, blood in the vessels of the most transparent parts I could select; and several observations on the web and lung of the frog and elsewhere were satisfactory. But still, when the cells were thus somewhat obscured by intervening membrane, one could not generally feel sure that the observation was so clear and complete, but that a faintly marked nucleus might escape detection. While, therefore, the result of observations on blood-cells in the vessels fully accords with the description I have given, I do not think that the demonstration of the fact, that while living they have no nucleus, can be made so plain and unequivocal as when they are removed from the vessels.

The question naturally arises, Why, then, does not a nucleus form in the mammalian corpuscle? But while it is accepted that the great majority of these corpuscles exhibit no nuclei after death, excellent observers still affirm their occasional existence; and I am convinced

* Made many years ago. Other observers have been unable to detect a nucleus in the living cells within the vessels.

that an indistinct, imperfectly formed "nucleus" is often seen; and the shadowy substance seen in many of the smaller oviparous cells after they have been mounted for some time is very like that seen under similar circumstances in some of the corpuscles of Mammalia. Many, too, affirm that these corpuscles do not exhibit that distinction of wall and contents which is generally described. It appears to me that this difference of opinion depends on the changes they are prone to undergo. How far the absence of a distinctly defined "nucleus" after death depends on their smaller size I am not prepared to say.

Many questions of course follow. For example, how far is this separation of the substance of a homogeneous * corpuscle into nucleus, cell-membrane, and contents to be compared to the coagulation of the blood? and how do the agents which are known to influence the one process affect the other? A still further and more important question is, How are these changes in the corpuscles, and in the blood around them, related? But in this paper I propose to go no further than the statement that the red corpuscle of all vertebrata is, in its natural state, structureless. When living, no distinction of parts can be recognized; and the existence of a nucleus in the red corpuscles of ovipara is due to changes after death, or removal from the vessels.

I cannot conclude this paper without acknowledging the great help I have received in this investigation from Mr. Howard Marsh, Demonstrator of Microscopical Anatomy at St. Bartholomew's Hospital.

MISCELLANEOUS.

Note on a new Hermaphrodite Chætopod Annelid. By G. Moquin-Tandon.

The group of Chætopod Annelida was long regarded as consisting entirely of unisexual animals. In 1857, Mr. Huxley made known the first exception to this general law in a new Annelid of the English coast, *Protula Dysteri*. A few years later, M. Pagenstecher, while staying on the shores of the Mediterranean at Cette, discovered the same fact in another species of the same family, *Spirorbis spirillum*. Lastly, a third fact of the same kind was observed by M. Claparède in a species of *Amphiglena* (*A. mediterranea*). This naturalist also confirmed the exactitude of Mr. Huxley's observations, and showed, by his investigation of a great number of Serpulea, that these cases of monœciousness are exceptional in this family.

I have discovered another example of hermaphroditism, but this time in a dorsibranchiate Annelid belonging to the genus *Nereis*. I believe that this species is new, and propose to name it *Nereis mas-*

* By the word homogeneous I do not mean to affirm that the substance of the corpuscle is of equal consistence throughout. The central may be the softest part of it. But I regard the corpuscle, in its whole substance, as "having the same nature."